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Hymenoptera Associated with Elm Bark Beetles in Wytham Wood, Berks.

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TRANSACTIONS OF THE SOCIETY
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Hymenoptera Associated with Elm Bark Beetles in Wytham Wood, Berks.

By R. A. Beaver

(Department of Zoology, University College of North Wales, Bangor).

Previous papers in this series (Beaver 1967 a, b) have reviewed the biology of the bark beetles attacking elm in Wytham Wood, Berks., and the associated Coleoptera. In this paper, I shall be concerned with the parasitic Hymenoptera found to attack the immature stages of the bark beetles *Scolytus scolytus* (F.), *S. multistriatus* (Marsh.) and *Pteleobius vittatus* (F.). No parasites of the adults were found.

Before dealing with the individual species certain general points may be mentioned. All species except the Eulophid *Entedon leucogramma* (Ratz.), which has been considered elsewhere (Beaver 1966), oviposit on Scolytid larvae or pupae through the bark. Because of this, the host must not lie deeper in the bark than the length of the ovipositor of the parasite. Bark thickness will therefore affect the level of parasitism, especially of the smaller species. *E. leucogramma* enters the Scolytid maternal gallery to oviposit in the eggs, so is not affected in this way.

The searching and oviposition behaviour of the Braconid and Chalcid parasites observed differs in a number of respects. The Braconid female moves fairly rapidly over the bark with her antennae extended but not tapping the bark. The Chalcid female moves slowly over the surface, her antennae bent down and rapidly tapping the bark. The Braconid female may remain inactive in one spot for up to half an hour between periods of rapid movement; the Chalcid searches almost continuously with breaks of only a few seconds. There is probably a fundamental difference in the method of detection of hosts in the two groups. It seems likely that the Braconids detect the vibrations set up by the Scolytid larvae feeding below the bark (Ryan & Rudinsky 1962). They were not found to attack the motionless pupae. On the other hand, the Chalcids attack pupae as well as larvae, and several are also known as hyperparasites of the Braconids. Clearly

vibrations are not necessary for host detection, but it is not clear whether the Chalcids detect the characteristic shape of the space around a bark beetle or parasite larva or pupa in the bark, or whether they respond to chemical stimuli. The characteristic rapid tapping of the antennae during searching would perhaps suggest the former possibility. When a host has been located, the Chalcid hesitates only slightly in her progress before lowering her ovipositor and starting to bore through the bark. The Braconid in contrast tends to move over the spot for some time and may change her position slightly after boring for a few minutes.

All the parasites except *E. leucogramma* develop ectoparasitically, and the size of the host larva has a very great effect on the size of the parasite produced. The adult size range is especially great among the Chalcids, e.g. the Pteromalid *Cheiropachus colon* (L.) varies in length from 1·5-5·0 mm. However, size seems to have no effect on mating. Small males mate successfully with large females and vice versa.

At least in the Braconid *Coeloides scolyticida* Wesm. the size of the host larva also affects the sex of the parasite. A greater proportion of males emerges from cocoons on smaller *S. scolytus* larvae. This effect has been noted also in *Coeloides brunneri* Vier. (Ryan & Rudinsky 1962), and in other parasitic Hymenoptera (Flanders 1939).

Due to the long overlapping generations of the hosts (Beaver 1967a), accurate correlation of the life cycles of host and parasite is not necessary. The emergence period of the parasites is in general prolonged over that of the host. Most species have at least a partial second generation emerging in late summer. All the parasites overwinter as larvae (the Braconids in cocoons) in the larval galleries of the host.

Detailed records of alternative hosts for the parasites will not be given. Extensive lists are available in Thompson (1943), Sachtleben (1952), Nuorteva (1957), Balazy & Michalski (1962) and Hedqvist (1963). In considering the host range, a useful distinction can often be made between habitual and occasional hosts. On the former, the parasite is common and regularly found; on the latter, the parasite is rare and the hosts seem to be attacked 'accidentally' by parasites straying outside their usual habitat. e.g. from deciduous to coniferous trees.

The immature stages of the parasites have their own enemies. There is the possibility of hyperparasitism. They are attacked by a number of subcortical predators which also attack the Scolytids. At Wytham, the most important of these were the larvae of two species of Dolichopodid fly—*Medetera impigra* Collin and *M. nitida* (Macq.). These ate many Chalcid larvae and even attacked Braconid larvae within their cocoons. Woodpeckers were also important predators.

Braconidae

Coeloides scolyticida Wesm.

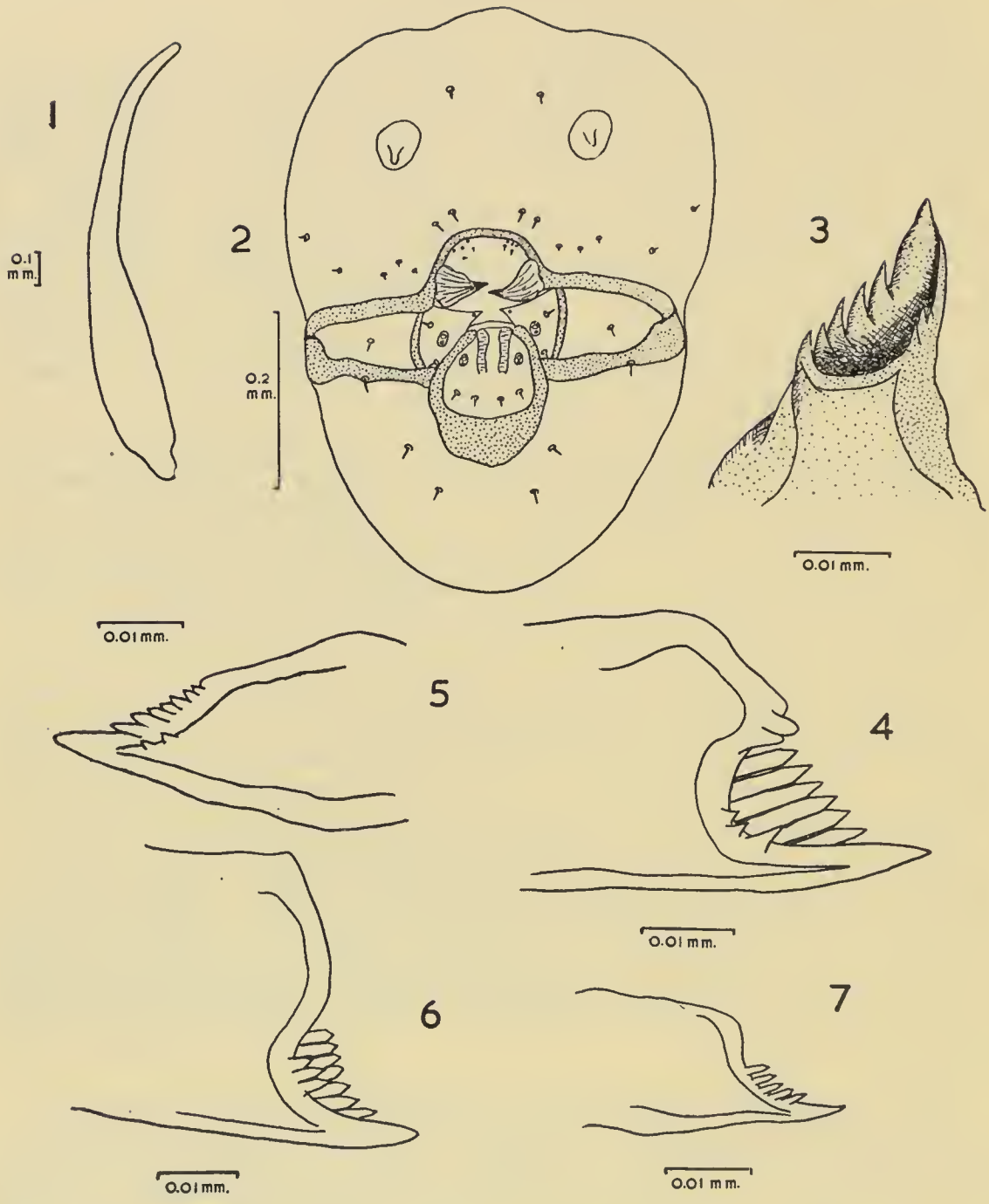
This was the most common parasite on *S. scolytus* and was also bred from *S. multistriatus*. It seems to be restricted in its habitual hosts to species of *Scolytus*. Records from bark beetles in conifers are probably due to confusion with *C. bostrichorum* Gir. (Sachtleben 1952), and records from other families of Coleoptera must be regarded as 'accidental'. The biology of a number of species of *Coeloides* has been studied (Taylor 1930, DeLeon 1935, Russo 1938, Lovászy 1941, Sachtleben 1952, Ryan & Rudinsky 1962). All are solitary ectoparasites of the larvae of Scolytids. The mating and oviposition behaviour of *C. scolyticida* does not differ from the other species.

At Wytham, first generation adults emerged in June and July. They attacked chiefly the 4-5 instar larvae of *S. scolytus,* and to a lesser extent the third instar. A partial second generation emerged in August and September, beginning a few days after the first emergence of second generation *S. scolytus* adults. Attacks ceased in mid-September and the remaining larvae overwintered in cocoons.

It will be shown elsewhere that the parasite showed a density-dependent response to the population density of *S. scolytus*. The precise way in which host density affected the searching parasite has not been investigated, but field observations showed that if a parasite detected and parasitised a host larva, it continued to search in the same area. If no host was found after a period of search, the parasite would usually fly off. This effect would in itself be sufficient to give a density-dependent response, but in addition, it is possible that the mere presence of an ovipositing female may cause other females to concentrate their searching in the same area (Ryan & Rudinsky 1962). This would further enhance the effect.

The immature stages of *C. scolyticida* resemble those of *C. subconcolor* Russo and *C. brunneri* described by Russo (1938) and Ryan (1962) respectively. The egg is shown in fig. 1. It measures $1{\cdot}8 \times 0{\cdot}2$ mm. and lacks the annular constrictions of the stalk shown by Russo in *C. subconcolor*. No features have been found that will distinguish the fifth (final) instar larva from that of *C. brunneri* (Ryan 1962). Certain features shown in figs. 2-4, and not in the figures of *C. brunneri* are in fact also present in that species (Ryan *in litt.*). The number and arrangement of the teeth on the mandibles is characteristic and can be used to distinguish between the Braconid larvae found in this study (figs. 4-7). The cocoon is yellowish-brown and thick-walled. No difference was found between the cocoons of diapause and non-diapause larvae. The pupa is similar to that of *C. subconcolor* (Russo 1938).

In the laboratory, the egg hatched after 2-3 days. The larva moved actively over the host in the early instars, but then



FIGS. 1-4—Immature stages of *Coeloides scolyticida*: 1, egg; 2, head capsule of last instar larva; 3, tip of last instar larval mandible from above; 4, larval mandible from side.

FIGS. 5-7—Mandibles of last instar larvae from side: 5, *Doryctes pomarius;* 6, *Dendrosoter protuberans;* 7, *Ecphylus silesiacus.*

settled anywhere on its body and began to grow rapidly. The host was consumed after 5-6 days and the larva then lay inactive for 2-3 days before constructing a cocoon. This process took 3-4 days. The pupal phase lasted 13-18 days, and the adults probably remained in the cocoon for a few days before biting their way out.

Dendrosoter protuberans (Nees)

The species was bred from *S. scolytus* and *S. multistriatus*. The biology of the species is similar to *C. scolyticida* and has been described by Russo (1938). It occurred much more rarely than *C. scolyticida* and there was a heavy infestation in only two logs. In these, *C. scolyticida* was almost absent, but the reason for this replacement of one species by the other is not known. The ovipositor is only about half the length of that of *C. scolyticida* (1·3-3·9 mm. (average 2·4 mm.) compared to 3·1-6·3 mm. (average 4·7 mm.)). In general, *D. protuberans* is likely to be restricted to logs with thinner bark than those attacked by *C. scolyticida*.

The egg, first and last instar larvae and pupa have been described in detail by Russo (1938). He does not mention the teeth on the mandible of the last instar larva. There is an outer row of three teeth and an inner row of seven teeth (fig. 6). This distinguishes the larva from those of other Braconids found in this study. The cocoon has thinner walls and is lighter in colour than that of *C. scolyticida*.

Doryctes pomarius Reinh.

This species is considered in Beaver (1965), but a few points may be added about the larva, since there is no information in the literature. Due to the lack of material, only the head capsule of the last instar larva has been studied. The arrangement of the setae and the shape of the sclerites is similar to *C. scolyticida* (fig. 2). The mandibles differ in having seven inner, and two tiny outer teeth (fig. 5). The cocoon is thick-walled and similar to that of *C. scolyticida*.

Ecphylus silesiacus (Ratz.) Russo

This species is considered in Beaver (1965). The immature stages have been described by Russo (1938). Again he omits the mandibular teeth. There is a single row of five small teeth (fig. 7).

Pteromalidae

Acrocormus semifasciatus Thoms.

This species is considered in Beaver (1965). It should be noted that the record from *Scolytus rugulosus* Müll. given there was wrongly quoted from Hedqvist (1963) and should read *Scolytus intricatus* (Ratz.). Since my paper was written, I have found that the species has also been recorded from *S. pygmaeus* (F.) (Balazy & Michalski 1962), and *S. ensifer* Eichh. (Michalski 1962). On the latter species, far from being rare, it was the most important parasite in the collections from one area. More than fifty individuals were obtained from the end of May to the beginning of July.

Cheiropachus colon (L.)

This species attacks a wide range of Scolytids in both deciduous and coniferous trees. It was bred from all three

Scolytids attacking elm. It has not previously been recorded from *P. vittatus.*

Adults were found in the field from June to October. There was a partial second generation emerging in August and September. An account of the biology and immature stages is given by Russo (1938). In the laboratory, the egg hatched in 1-2 days. The larva completed its development in 8-10 days. In the non-diapause larva there was a period of 3-6 days before pupation. The pupal phase lasted 14-16 days.

Dinotiscus aponius (Walk.) (=*D. bidentulus* Thoms.)

The species has been bred from all three Scolytids attacking elm. *P. vittatus* is a new host record. The species appears to be effectively confined to Scolytids living in deciduous trees, although there are records of occasional specimens bred from bark beetles in conifers. The species is recorded as a hyperparasite of the Braconids *Coeloides filiformis* (Ratz.), *C. melanotus* Wesm. and *Dendrosoter protuberans* (Jamnicky 1959, Szczepanski 1960). There was no indication of hyperparasitism by *D. aponius* in this study.

The biology is similar to *C. colon.* It attacked chiefly the third to fifth instar larvae of *S. scolytus,* but a few attacks on second instar larvae and on pupae were noted. There was a partial second generation.

An interesting feature of the behaviour of *D. aponius* and *C. colon* is the tendency to show aggressive behaviour towards other individuals of the same or different species both in the laboratory and in the field. In the laboratory, when several adults are confined together in a glass tube with a small amount of food, a 'peck order' is set up after mating has occurred. Individuals lower in the order are chased away from the food by individuals higher in the order. In general, females are higher in the order than males and larger females are higher than smaller ones. However, this is not invariably the case.

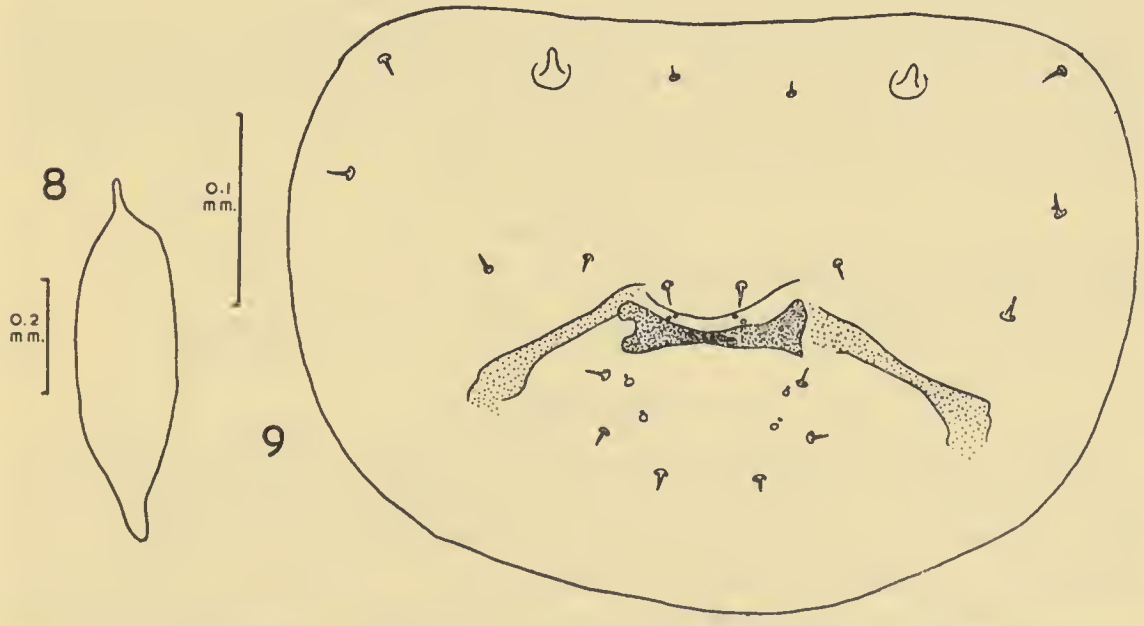
In the full threat posture, the attacking individual faces its opponent with the wings held almost vertically over the back and turned somewhat forward so that the dark markings on them are visible to the other individual. The abdomen is raised and visible from the front between the wings. The head is stretched forward and the mandibles opened wide. The antennae are held extended and parallel and flicked up and down regularly. If the display is at all prolonged, the wings are raised and lowered every few seconds and the attacker may dart forward a little way at its opponent. The latter usually retreats immediately. Sometimes the mere raising of the wings over the back is sufficient to repel the other. No attempt was seen to use the mandibles on a live opponent, but when a male which had died in a fairly life-like position but with the wings raised over the back, was introduced into a tube containing a female, it was gripped and pulled by her. Possibly this more aggressive behaviour was due to the lack of

response by the dead male, which might normally have been expected to retreat.

Similar behaviour occurs in the field when the females are searching for hosts. Another Chalcid or even Braconid female which approaches too near is driven away. A similar threat posture is used. In only one case was an actual attack noted. Two female *D. aponius* met face to face and attacked simultaneously. The resulting mêlée lasted for a few seconds, then one female flew off 15-20 cm. and both continued searching.

I have since observed similar behaviour in *Rhopalicus tutele* (Walk.), a parasite of bark beetles attacking conifers. Hedqvist (1963) notes similar behaviour in *Dinotiscus calcaratus* (Thoms.) driving away *Eurytoma arctica* Thoms. However, among bark beetle parasites, such behaviour has not been observed outside this group of the Pteromalidae.

The immature stages were not distinguishable from those of *C. colon*. The egg is shown in fig. 8 and the head capsule of a last instar larva in fig. 9. The periods spent in the various stages of development are the same as in *C. colon*.



FIGS. 8-9—Immature stages of *Dinotiscus aponius*: 8, egg; 9, head capsule of last instar larva.

Eurytomidae

Eurytoma morio Boh.

This species was bred from *S. scolytus* (1♀) and *P. vittatus* (1♂). Both are new host records. The recorded hosts include a wide variety of Scolytids on both deciduous and coniferous trees. It has also been bred as a hyperparasite of *Coeloides* species (Sitowski 1933, Jamnicky 1959). The species was abundant in Wytham as a parasite of *Leperesinus fraxini* (Panz.) on ash (Elton 1966), and its occurrence on elm seems to have been

'accidental'. Some information on the biology is given in Lovászy (1941) and Nuorteva (1957).

The last instar larva is briefly described and figured by Lovászy (1941). He distinguishes it from those of *E. arctica* (given as *E. rufipes* Walk., but see Hedqvist (1963)), and *E. curculionum* Mayr by the possession of mandibles with a parallel-sided basal part. In my own preparation of a larva, from which the adult was bred, the mandibles resemble more closely Lovászy's figure for *E. arctica,* and are not parallel-sided at the base. The differences Lovászy notes between the species may be partly due to the angle at which the mandibles are lying.

Eupelmidae

Eupelmus urozonus Dalm.

This species has an extremely wide range of recorded hosts including Lepidoptera, Diptera, Hymenoptera and Coleoptera. It occurs both as a primary and a secondary parasite. Three females were bred from *S. scolytus,* but in only one case was the relation to the host discovered. A first or second instar larva of *E. urozonus* was found feeding on a fully grown Chalcid larva, almost certainly *D. aponius,* which had previously parasitised a fifth instar larva of *S. scolytus.* The ectoparasitic larva consumed its host in 9-10 days, and remained 3 days before pupating. Accounts of the biology and immature stages are given by Askew (1961) and Delanoue & Arambourg (1965).

Eulophidae

Entedon leucogramma (Ratz.)

This species is considered in detail in Beaver (1966).

Summary

The biology of a number of hymenopteran parasites of elm bark beetles is discussed and some new host records are given. The searching and oviposition behaviour of the Braconids and Chalcids is contrasted, and the occurrence of aggressive behaviour in certain of the Pteromalids described. Where possible, information is given on the development and distinguishing characters of the immature stages. It is shown that the number and arrangement of the teeth on the mandibles of the Braconid larvae are useful characters for generic distinctions.

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